

**Comparative Economic  
Analysis of  
Completing Nuclear  
Construction  
or  
Pursuing a Natural Gas  
Resource Strategy**

**May 26, 2015**



## **Introduction**

The purpose of this study is to determine if abandoning SCE&G's ongoing nuclear construction program and pursuing a natural gas generation strategy for base load generation needs would benefit retail customers in terms of long-run revenue requirements. SCE&G's management directed the Resource Planning Department to use current data to prepare generation cost studies comparable to those performed in 2008 that supported the original decision to construct the two nuclear units (the Units).

SCE&G has undertaken this exercise expressly reaffirming its position that no single analysis of comparative costs underlies its choice of nuclear generation over gas fired generation alternatives. The goal of base load generation planning is to create a diverse and flexible portfolio of generation units that can perform effectively in multiple sets of conditions over 40 years or more. No single study or series of studies is an effective substitute for informed business judgment exercised with this goal in mind.

This study calculates the incremental revenue requirements on a comparative basis for two strategies. The first is the base case which involves completing the two nuclear units which are presently under construction and scheduled to go into service in 2019 and 2020. When completed, the Units together will provide SCE&G with 1,229 MW. The second strategy is the natural gas resource strategy in which the Units are cancelled at the effective date of March 31, 2015. The Units are replaced by two combined cycle units rated at 614 MWs each which come into service in 2019 and 2020 also.

The principal components of the study and conclusion are set forth below. The inputs to the study have been updated to reflect the most current values available.

## **Load Forecast and Resource Plans**

To compute the revenue requirements of the two strategies over a 40-year planning horizon, the study relies on the load forecast data that were reported in summary form in SCE&G's 2015 Integrated Resource Plan. These load forecasts are updated versions of those that were used in the 2008 planning studies (the 2008 Studies) on which the original Base Load Review Act (BLRA) order was based. Both the nuclear and gas resource strategies are measured against identical load forecasts.

Appendix 1 shows the forecast and the base case scenario resource plan. Both the nuclear capacity and the natural gas combined-cycle capacity are shown on the alternative versions of the resource plan as "base load" capacity entered on line 10 in the table shown in Appendix 1. As was the case with the 2008 Studies, the resource plans for each of the two strategies assumed that, after the base load capacity was added, additional simple-cycle natural gas-fired generation was added to meet subsequent load growth. Comparable amounts of simple cycle generation with comparable capital cost and operating costs were added under each strategy.



## **Abandoning Nuclear Construction**

As of March 31, 2015, SCE&G expects to have spent \$3.101 billion on construction of the Units. If SCE&G were to decide to cancel the nuclear construction project, it would be subject to contractual cancellation charges, site decommissioning and stabilization expenses and other abandonment expenses in addition to the \$3.101 billion that would already have been spent. SCE&G's best assessment of the amount of those cancellation expenses would be \$1.033 billion for a cancellation effective December 31, 2014. This is the cost on a 100% basis (i.e., including Santee Cooper's 45% share in expenses).

Upon cancellation of the project, SCE&G could scrap, sell or salvage certain materials, equipment and work in progress and could use the proceeds to off-set some part of the abandonment expenses. A large component of the spending to date, however, has been for site work, construction of roads, building and bridges on site, the hiring and training of personnel, design and procurement work, and other activities that do not produce salvageable materials. SCE&G estimates that of the amounts spent to date, the salvage value of materials, equipment and work in progress would be approximately \$515.8 million on a 100% basis. This \$515.8 million would be netted against the gross cancellation cost of \$1.033 billion to produce an estimate of the net cancellation cost, not considering the \$3.101 billion already spent, of \$517 million, again on a 100% basis. SCE&G's customers would be responsible for 55% of this cost or \$284 million.

Thus, adding the \$3.101 billion spent as of March 31, 2015, and the \$284 million in net cancellation costs, the total abandonment cost is estimated to be \$3.385 billion.

The model used for comparing the costs of these two strategies computes a levelized cost for capital invested that includes all relevant parameters given the nature of the asset involved. This combination of costs spent to date and additional cost to abandon the project represent a cost that must be borne by the gas resource strategy.

## **Benefit of a Balanced Capacity Portfolio**

A significant advantage of continuing construction of the two nuclear units is that once added to SCE&G's generation fleet, the Units will produce a well balanced capacity portfolio. The following charts show the percent distribution of capacity under a plan of continuing nuclear construction and the alternative of replacing it with natural gas fired capacity.

**CHART A**

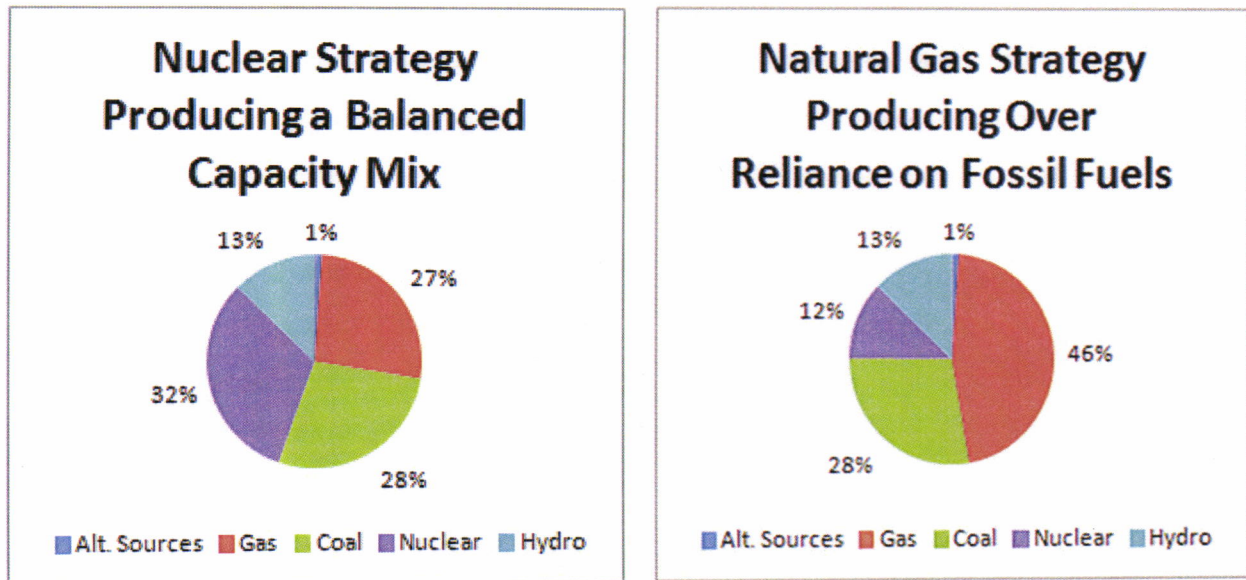


Chart A shows that the Natural Gas Strategy produces a generation system that in 2021 relies on fossil fuels for 73% of its generating capacity. The Nuclear Strategy creates a more balanced portfolio. Such a portfolio better protects customers from unexpectedly high costs in any one fuel source while allowing the utility to take advantage of opportunities in others.

### **Price of Natural Gas**

Chart B shows two forecasts of natural gas prices at the Henry Hub. One is the current Energy Information Administration (EIA) natural gas forecast reported in their 2015 Annual Energy Outlook (AEO). The second is the proprietary natural gas forecast that SCE&G uses for planning purposes. To develop this forecast, SCE&G uses the forward prices reported for the NYMEX futures contracts over the next three years (i.e., through the end of 2018) and then applies an escalation factor projected by the economic forecasting firm IHS Global Insight Inc. to forecast prices beyond three years in the future. This is a methodology that SCE&G has used for a number of years to produce gas forecasts for planning studies. The value of this methodology is that it is simple and objective. However, because all forecasts of future gas prices are subject to error, SCE&G typically tests the results of these studies done using these forecasts through sensitivity analyses that model variations in gas prices.

The SCE&G natural gas price forecast is the lowest of the forecasts reported on Charts B and G. It is the forecast used in these studies as the base case value for future gas prices. Charts B and C compare SCE&G baseline natural gas price forecast to the EIA's forecast that was provided in their 2015 Annual Energy Outlook.

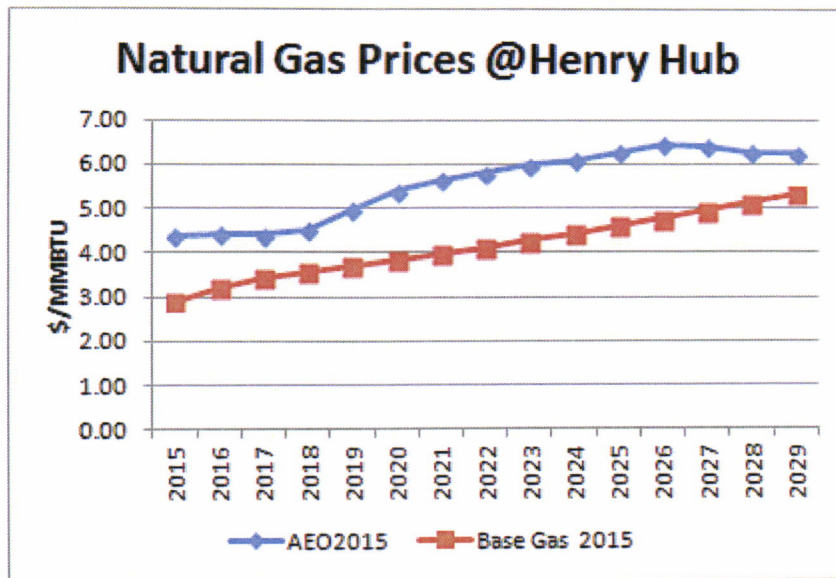


## CHART B

	Natural Gas Price Forecasts @Henry Hub (\$ per MMBTU)						
	2016	2017	2018	2019	2020	2030	2035
SCEG Baseline	3.22	3.44	3.56	3.70	3.83	5.51	6.60
EIA 2015 Forecast	4.42	4.40	4.53	4.96	5.39	6.22	6.98

Chart C graph compares SCE&G's baseline forecast to that of the EIA.

## CHART C



## Social Cost of Carbon

In 2009, the Obama Administration convened a group of federal agencies to establish a social cost for CO<sub>2</sub> to be used in future rulemaking by federal agencies. In 2010, this interagency committee published its first social cost of carbon ("SCC"), a monetized value associated with the cost of emitting a ton of CO<sub>2</sub>. In 2013 the interagency working group published an updated report with new estimates of the social cost of carbon.<sup>1</sup> Following is a copy of a table from the government's report on SCC estimates summarizing their results:

<sup>1</sup> Whitehouse Report: "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866"

[https://www.whitehouse.gov/sites/default/files/omb/inforeg/social\\_cost\\_of\\_carbon\\_for\\_ria\\_2013\\_update.pdf](https://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf)

**Revised Social Cost of CO<sub>2</sub>, 2010 – 2050 (in 2007 dollars per metric ton of CO<sub>2</sub>)**

Discount Rate	5.0%	3.0%	2.5%	3.0%
Year	Avg	Avg	Avg	95th
2010	11	33	52	90
2015	12	38	58	109
2020	12	43	65	129
2025	14	48	70	144
2030	16	52	76	159
2035	19	57	81	176
2040	21	62	87	192
2045	24	66	92	206
2050	27	71	98	221

The cost of carbon emissions shown in the above table are stated in 2007\$. The following table restates the costs in nominal dollars assuming an inflation rate of 2% and includes the costs used in SCE&G's study.

Discount Rate	Social Cost of CO <sub>2</sub> in Nominal Dollars				SCE&G's Study	
	5.0%	3.0%	2.5%	3.0%		
Year	Avg	Avg	Avg	95th	\$15/Ton	\$30/ton
2010	12	35	55	96		
2015	14	45	68	128		
2020	16	56	84	167	\$15	\$30
2025	20	69	100	206	\$19	\$38
2030	25	82	120	251	\$24	\$49
2035	33	99	141	306	\$31	\$62
2040	40	119	167	369	\$40	\$80
2045	51	140	195	437	\$51	\$102
2050	63	166	230	518	\$65	\$130

SCE&G's scenario of \$15 per ton is very close to the lowest government estimates for SCC based on a social discount rate of 5.0%. Both of SCE&G's scenarios, the \$15 and \$30 scenarios, are below the SCC values recommended for government use i.e. those based on a 3.0% discount rate and are well below the high estimates based on a 2.5% social discount rate and the 95<sup>th</sup> percentile in the 3.0% discount case.

## Capital Costs and Operating Costs of Natural Gas Capacity

The gas resource strategy relies on combined cycle plants for additional base load generation. As mentioned above, both the nuclear and natural gas resource strategies add simple cycle combustion turbines to meet additional capacity needs. Chart F contains the costs and heat rates assumed for these units. These inputs are based on SCE&G's ongoing monitoring of equipment and construction prices and are verified through reviews of published prices and



vendor discussions. They reflect current costs to engineer, procure and construct the assets in question including land costs, pipeline connection costs, transmission costs and permitting costs.

#### CHART F

Gas Technology	Capacity Rating MW	Construction Cost \$/KW	Heat Rate BTU/KWH	Fixed O&M Per Year	Variable O&M Per MWH
Simple Cycle	93	\$740	9,169	\$63,400	\$1.36
Combined Cycle	614	\$1,083	6,862	\$8,833,000	\$1.29

#### Miscellaneous Inputs

In this study, all carrying costs on capital investments are calculated including taxes, depreciation, insurance and cost of capital as applicable to the type of asset in question. Fixed and variable O&M are based on current estimates of turbine maintenance costs for combined cycle units. Nuclear production tax credits have been updated. Nuclear fuel costs are based on current forecasts of uranium prices and prices of new fuel assembly fabrication.

#### Scenario Analysis

In this study, the nuclear strategy and the natural gas resource strategies were studied under 27 different scenarios: three different natural gas prices, three different costs per ton of CO<sub>2</sub> emitted and three different levels of load on SCE&G's system.

**a. Natural Gas Price Scenarios** - The natural gas scenarios included the base line forecast of future natural gas prices as previously discussed as well as prices reflecting a 50% and 100% increase in the base line forecast. These three gas scenarios quantify the sensitivity of the analysis to variable natural gas prices. Chart G shows the natural gas price for each scenario for several years in the forecast period, as well as EIA's projection for reference.

#### CHART G

Natural Gas Price Forecasts @Henry Hub (\$ per MMBTU)							
	2016	2017	2018	2019	2020	2030	2035
SCEG Baseline	3.22	3.44	3.56	3.70	3.83	5.51	6.60
50% Higher Scenario	4.83	5.16	5.35	5.54	5.75	8.26	9.90
100% Higher Scenario	6.64	6.88	7.13	7.39	7.67	11.02	13.20
EIA 2015 Forecast	4.42	4.40	4.53	4.96	5.39	6.22	6.98

The EIA forecast of natural gas prices falls between SCE&G's baseline forecast and the 50% higher scenario.

**b. CO<sub>2</sub> Cost Scenarios** - In light of current national environmental policies, it is clear that there will be a cost associated with the emissions of CO<sub>2</sub> in the future. The EPA's Clean Power Plan, which is expected to be finalized this summer, puts a cap on the level of emissions.

It remains to be seen whether or not a fully fledged cap and trade system will ultimately develop. In any case utilities will incur costs to lower their emissions of CO<sub>2</sub>, certainly in the uneconomic dispatch of their generation fleets and probably through the early retirement of coal units and new investment in replacement capacity. In the present study there were three CO<sub>2</sub> cost scenarios used: \$0, \$15 and \$30 per ton beginning in 2020 and escalating at 5%.

CO<sub>2</sub> costs at \$0 per ton are not a realistic expectation for the long term. However, the \$0 per ton CO<sub>2</sub> scenario provides a useful lower bound to test the sensitivity of the study to this input. The scenarios with \$15 and \$30 per ton will provide a sensitivity to the emissions cost. Both numbers are below the Social Cost of Carbon set by the government as mentioned previously.

**c. Load Forecasts Scenarios** - Three scenarios representing variations of the base case load forecast scenarios were modeled. They included the base case forecast and load forecast scenarios where the load was 5% higher and 5% lower than the base case. These higher and lower load scenarios were modeled to test the sensitivity of the analysis to variability in load due to factors such as increased economic activity or increased rates of energy conservation. The 5% plus or minus load scenarios provide for a reasonable assessment of possible variation in load on the system.

## **Dispatch Modeling**

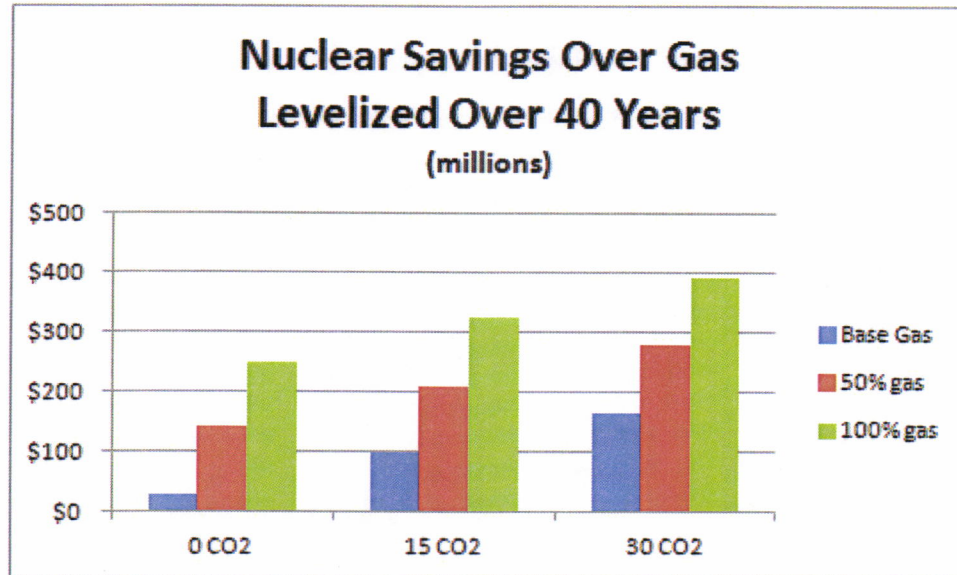
For each of the 54 combinations of 27 scenarios and 2 generation strategies, a simulation of the generation system dispatch was run using the PROSYM dispatch model. The PROSYM model is licensed from Ventyx and is widely used in the utility industry. This model determined how each generation resource on the system would be dispatched under each scenario over the 40 year planning horizon. Modeling the dispatch of the system using the PROSYM model produced both fuel cost and variable O&M costs for each scenario for each of the 40 years of the planning period. These fuel costs and variable O&M costs generated by the PROSYM model were then combined with the capital costs and other fixed costs for each scenario to determine a levelized annual cost for each of the 27 scenarios over the 40 year planning horizon.

## **Scenario Results**

The results of the modeling are set forth below in Chart H. This chart shows the savings from continuing to construct the Units based on three sets of assumptions as to future gas prices, and based on CO<sub>2</sub> costs of \$0, \$15 and \$30 evaluated against SCE&G's base case scenario for future load. SCE&G believes that the most reasonable scenario for planning purposes is the scenario that models a \$30 CO<sub>2</sub> cost and gas prices that are 50% higher than the current SCE&G gas forecast. That analysis shows that the nuclear strategy is less costly than gas by a levelized amount of \$278 million per year for 40 years.



**CHART H**



The numerical results of the scenarios shown in Chart H are set forth in Chart I below:

**CHART I**

**Base Load Scenario**

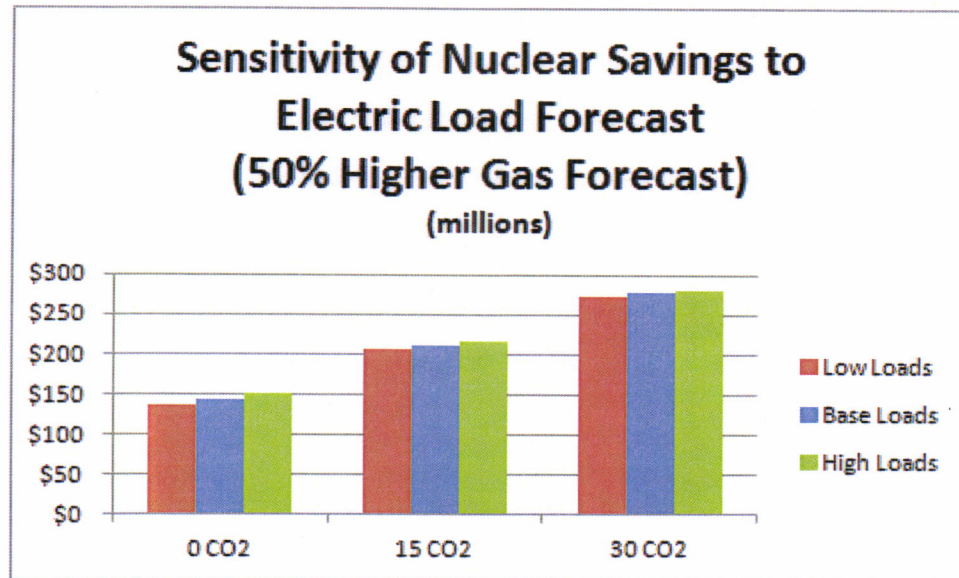
Benefit of Nuclear Strategy over the Gas Strategy Levelized Present Worth of Change in Revenue Requirements Over 40 Years (\$MM)			
	Base Gas	50% Higher Gas	100% Higher Gas
\$0 CO2 Price	\$28	\$144	\$248
\$15 CO2 Price	\$97	\$210	\$326
\$30 CO2 Price	\$166	\$278	\$392

This Chart highlights several critical points. First, completing the nuclear construction program is more economical than switching to a gas resource strategy across all scenarios modeled. In not one case is gas less costly than nuclear. The lowest level of nuclear advantage is a levelized annual advantage of approximately \$28 million per year. This occurs using base gas price assumptions and CO<sub>2</sub> prices at \$0 per ton. In the 2008 Studies, the \$0 per ton CO<sub>2</sub> scenario with low gas prices resulted in nuclear being more costly than gas by \$44 million.

In this series of scenarios, the nuclear strategy had the highest cost advantage over gas in the 100% Higher Gas scenario with a \$30 per ton CO<sub>2</sub> price. In that scenario, the nuclear strategy was more cost effective than the gas resource strategy by a levelized amount of \$392 million per year. As mentioned above, the scenario with the set of assumptions that SCE&G believes to be most reasonable for planning purposes is 50% higher gas prices with \$30 per ton CO<sub>2</sub> where nuclear has a cost advantage over gas of \$278 million per year.

Studies were run with different assumptions as to future levels of system load to determine whether the studies' results were sensitive to changes in future electric load forecasts. Chart J shows results calculated using the base load forecast side by side with result calculated using load forecasts that have been increased by 5% and decreased by 5%. The chart shows very little variability in results based on changes in the load forecast.

**CHART J**



The scenario results reported on Chart J are for the 50% Higher Gas scenario. The Base Gas and 100% Higher Gas scenarios were modeled in the same way. The resulting charts are attached as Appendix 2 and the underlying data is attached as Appendix 3. They show a similar alignment of results. Collectively, these charts show that the cost advantage of the nuclear strategy over the natural gas resource strategy is consistent whether electric loads are greater or less than anticipated in the future.

There are several other inferences that can be drawn from these results of testing the nuclear and the gas resource strategies across these 27 scenarios. First, the advantage that the nuclear strategy has over the gas strategy is not dependent on load growth forecasts. Forecasts for load growth are currently very low. But even if the current load growth projections turn out to be high because of DSM, energy efficiency or distributed or alternative generation, the nuclear advantage is not materially reduced.

Second, the study shows that the comparative economics of the nuclear and natural gas resource strategies swing widely based on gas price forecasts and future CO<sub>2</sub> cost assumptions. This shows that the economics of the gas resource strategy are very sensitive to swings in natural gas prices and CO<sub>2</sub> costs. This confirms that a resource strategy dependent of natural gas generation significantly increases SCE&G's exposure to fossil-fuel volatility and environmental cost increases.



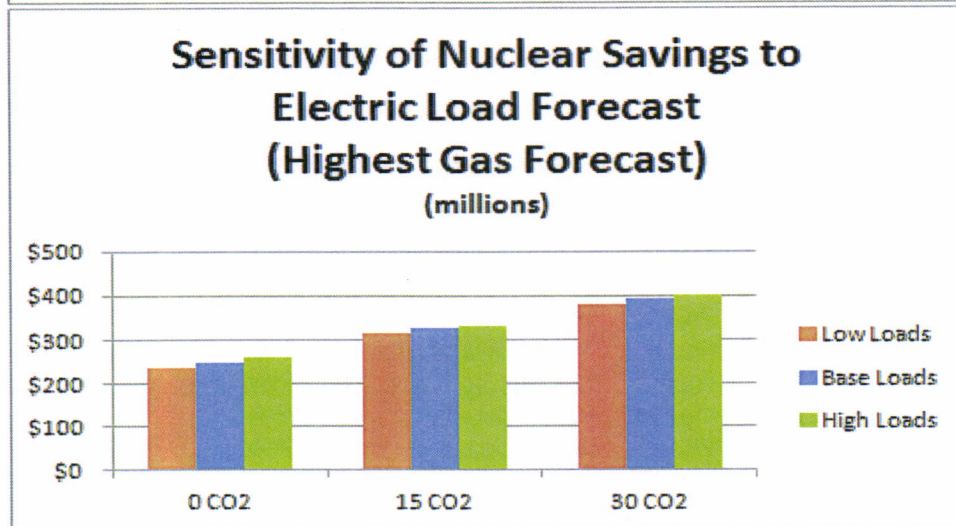
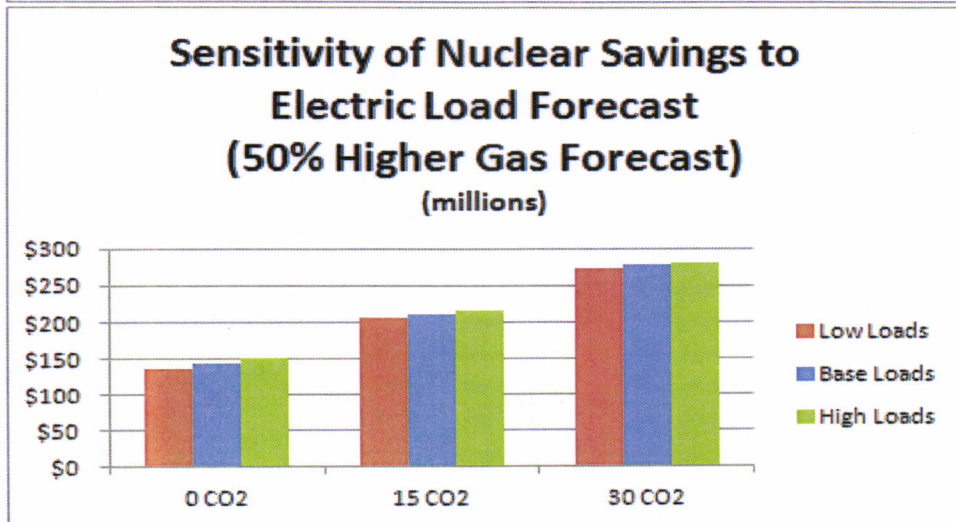
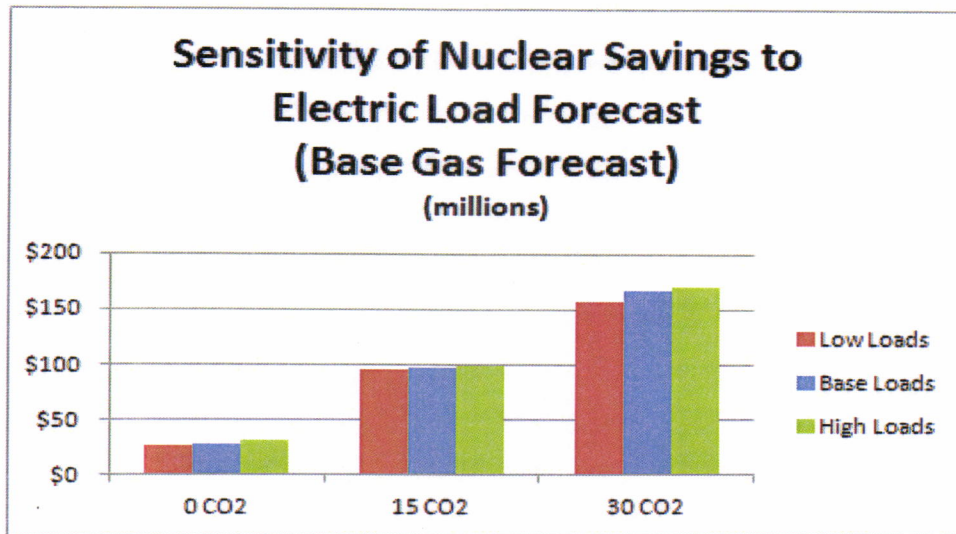
## **Conclusion**

The results of this study demonstrate through the use of a full system dispatch model, run over a 40 year planning cycle, and using updated information on relevant parameters that the nuclear strategy remains the strategy best able to provide favorable results over a broad range of future operating conditions. The most reasonable estimate of the cost advantage of completing the Units is \$278 million per year for 40 years.

SCE&G Forecast of Summer Loads and Resources - Basecase Nuclear Resource Plan																
(MW)																
	YEAR	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Load Forecast																
1	Baseline Trend	5006	5089	5212	5341	5467	5595	5719	5833	5950	6059	6162	6268	6366	6460	6559
2	EE Impact	-3	-8	-22	-36	-50	-62	-74	-86	-98	-111	-123	-136	-149	-163	-176
3	Gross Territorial Peak	5003	5081	5190	5305	5417	5533	5645	5747	5852	5948	6039	6132	6217	6297	6383
4	Demand Response	-256	-259	-265	-272	-275	-277	-280	-283	-286	-289	-292	-295	-298	-301	-304
5	Net Territorial Peak	4747	4822	4925	5033	5142	5256	5365	5464	5566	5659	5747	5837	5919	5996	6079
System Capacity																
6	Existing	5282	5289	5308	5314	5320	5940	6215	6215	6308	6401	6494	6587	6680	6773	6866
Additions:																
7	Solar Plant (2% DER)	7	19	6	6	6	6		93	93	93	93	93	93	93	93
8	Peaking/Intermediate															
9	Baseload					614	614									
10	Retirements						-345									
Total System Capacity																
11	Total System Capacity	5289	5308	5314	5320	5940	6215	6215	6308	6401	6494	6587	6680	6773	6866	6959
12	Firm Annual Purchase	300	300	300	425											
13	Total Production Capability	5589	5608	5614	5745	5940	6215	6215	6308	6401	6494	6587	6680	6773	6866	6959
Reserves																
14	Margin (L13-L5)	842	786	689	712	798	959	850	844	835	835	840	843	854	870	880
15	% Reserve Margin (L14/L5)	17.7%	16.3%	14.0%	14.1%	15.5%	18.2%	15.8%	15.4%	15.0%	14.8%	14.6%	14.4%	14.4%	14.5%	14.5%



## Sensitivity of Nuclear Savings to Electric Load Forecast



**Benefit of Nuclear Strategy over the Gas Strategy  
Levelized Present Worth of Change in Revenue  
Requirements Over 40 Years  
(\$MM)**

**Base Load Scenario**

	<b>Base Gas</b>	<b>50% Higher Gas</b>	<b>100% Higher Gas</b>
<b>\$0 CO2 Price</b>	<b>\$28</b>	<b>\$144</b>	<b>\$248</b>
<b>\$15 CO2 Price</b>	<b>\$97</b>	<b>\$210</b>	<b>\$326</b>
<b>\$30 CO2 Price</b>	<b>\$166</b>	<b>\$278</b>	<b>\$392</b>

**High Load Scenario**

	<b>Base Gas</b>	<b>50% Higher Gas</b>	<b>100% Higher Gas</b>
<b>\$0 CO2 Price</b>	<b>\$30</b>	<b>\$150</b>	<b>\$260</b>
<b>\$15 CO2 Price</b>	<b>\$98</b>	<b>\$215</b>	<b>\$335</b>
<b>\$30 CO2 Price</b>	<b>\$170</b>	<b>\$281</b>	<b>\$400</b>

**Low Load Scenario**

	<b>Base Gas</b>	<b>50% Higher Gas</b>	<b>100% Higher Gas</b>
<b>\$0 CO2 Price</b>	<b>\$26</b>	<b>\$137</b>	<b>\$233</b>
<b>\$15 CO2 Price</b>	<b>\$95</b>	<b>\$205</b>	<b>\$315</b>
<b>\$30 CO2 Price</b>	<b>\$157</b>	<b>\$273</b>	<b>\$382</b>